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(54) Title of the Invention: Solid-state Imaging Device

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DESCRIPTION

1. Title of the Invention

Solid-state Imaging Device

2. Claims

In a solid-state imaging device, in which picture elements, which use CMD photoreceptor elements having an internal amplification function as photoelectric conversion elements, are disposed in a matrix, and comprising a gate line for connecting in common gate electrodes of the CMD photoreceptor elements that are aligned in one direction, the solid-state imaging device characterized in that the gate electrodes of a plurality of adjacent CMD photoreceptor elements are connected to the gate line by one gate contact.

3. Detailed Description of the Invention

(Field of Industrial Application)

This invention relates to a solid-state imaging device that controls channel current by way of changes in potential resulting from accumulation of photogenerated charge, and comprises picture elements wherein CMD (Charge Modulation Device) photoreceptor elements, which have an internal amplification function and are capable of nondestructive readout, are used as photoelectric conversion elements.

(Prior Art)

CCD and MOS type imaging elements are known as conventional solid-state imaging elements; both of these have a constitution wherein a photogenerated charge that has accumulated in a photodiode is directly transferred to an output, and read directly as a signal charge. Consequently these elements present a disadvantage in that the S/N ratio of the output signal is degraded if the size of the elements is reduced or the number of elements is increased.

In light of this, the present inventors have previously proposed CMD photoreceptor elements wherein each picture element has an amplification function and is capable of nondestructive readout. Detailed technical information for this CMD photoreceptor element is given in a paper titled "A NEW MOS IMAGE SENSOR OPERATING IN A NON-DESTRUCTIVE READOUT MODE" pp. 353 to 356 of the proceedings of the International Electron Device Meeting (IEDM), published in 1986.

The planar structure and the sectional structure of one example of the constitution of a solid-state imaging device using such CMD photoreceptor elements as picture elements are shown in figure 5 (A) and (B). In the drawings, 101 is a p^- substrate; 102 is a channel layer comprising an n^- epitaxial

layer formed on this substrate 101; 103 is a source region comprising an n^+ diffusion layer; 104 is a shallow drain region comprising a shallow n^+ diffusion layer; 105 is a deep drain region that functions as a separation region and comprises a deep n^+ diffusion layer; 106 is an insulating film; 107 is a gate electrode formed so as to surround the source region 103; 108 is a common gate line; 109 is a common source line; 110 is a wire comprising a thin metal film for connecting the gate electrodes 107 and the gate lines 108; and 111 is a source electrode. The CMD photoreceptor element that constitutes the picture element has a planar structure wherein the source region 103, the gate electrode 107, and the shallow and deep drain regions 104 and 105 are disposed concentrically; the gate electrodes 107 of each picture element are horizontally connected by the common gate line 108 and the source regions 103 are vertically connected by the common source line 109.

During photoreception and readout, the CMD photoreceptor elements operate as bulk channel MOS transistors, with photogenerated positive holes accumulating directly below the gate electrode 107 to form an inversion layer. When this inversion layer is not formed, a potential barrier is formed in the bulk channel as a result of the negative potential applied to the gate electrode 107, so that electron current does not flow from the source region 103 to the drain regions 104 and 105. Conversely, when an inversion layer is formed as a result of photoirradiation, the height of the potential barrier in the bulk channel is lowered so that an electronic current can flow, this being modulated according to the number of positive holes in the inversion layer.

Accordingly, it is possible to detect the amount of incident light as a change in voltage, by connecting the gate line 108 to a vertical scanning circuit and connecting the source line 109 to a horizontal scanning circuit by way of a MOS selector switch, so that the source current for a picture element in the row selected by the horizontal scanning circuit, among those picture elements connected to the gate line that is selected by the vertical scanning circuit, flows through a video line as a negative charge.

(Problems to Be Solved by the Invention)

It should be noted that, in conventional solid-state imaging devices using CMD photoreceptor elements as picture elements, the gate electrodes are so constituted that each of the gate electrodes for the multiplicity of CMD photoreceptor elements that constitute the picture elements are connected to the gate line by a gate contact. Accordingly, the gate contact parts represent an extremely large amount of the surface area of the overall solid-state imaging device, making it difficult to increase the picture element density, and [thus] problems existed in that it was not possible to achieve good picture quality in situations requiring small chip size.

The present invention is directed at eliminating the aforementioned problems in conventional solid-state imaging devices using CMD photoreceptor elements as picture elements, and an object thereof is to reduce the surface area occupied by gate contact parts in solid-state imaging devices, so as to provide a solid-state imaging device using CMD photoreceptor elements that allows for increased picture element density.

(Means for Solving the Problems and Operation)

In order to solve the aforementioned problems, the present invention has a constitution wherein the gate electrodes of a plurality of adjacent CMD photoreceptor elements are connected to the gate line by one gate contact.

By virtue of such a constitution, it is possible to reduce the surface area of the gate contact parts and to reduce the size of the chip, allowing for increased picture element density and making it easily possible to produce a compact and high-quality solid-state imaging device using CMD photoreceptor elements.

Next, the present invention is described in more concrete terms with reference to the schematic view shown in figure 1, which illustrates the basic constitution of the present invention; extensions 3_{-1a} and 3_{-2a}, which extend obliquely, and so as to intersect, from gate electrodes 3_{-1} and 3_{-2}, which are formed so as to surround the source regions 2 of the CMD photoreceptor elements constituting two horizontally adjacent picture elements 1_{-1} and 1_{-2}, form a single-bodied cross-joining part 4. Next, this gate electrode cross-joining part 4 is connected to a common gate line 5, which is disposed between horizontal picture element rows, by way of one gate contact 6. Note that, in figure 1, 7 is a shallow drain region and 8 is a deep drain region, which forms a separation region. Thus, by connecting the gate electrodes of two picture elements to the gate line by way of one gate contact, the surface area of the gate contact parts can be halved.

(Embodiments)

Hereinafter, embodiments are described. Figure 2 is a view illustrating the planar structure of one embodiment of a solid-state imaging device according to the present invention. In the figure, 1_{-1} and 1_{-2} are picture elements comprising horizontally aligned adjacent CMD photoreceptor elements; 2 is a source region; 3_{-1} and 3_{-2} are gate electrodes formed from a first polysilicon so as to surround the source regions 2 in each of the picture elements 1_{-1} and 1_{-2}; and extensions 3_{-1a} and 3_{-2a}, which extend obliquely, and so as to intersect, from the gate electrodes 3_{-1} and 3_{-2}, form a gate electrode joining part 4. [Reference numeral] 5 is a gate line formed from a second polysilicon and disposed so as to pass over the gate electrode joining part 4, running between rows of horizontally aligned picture elements, and this gate line 5 is connected to the gate electrode joining part 4 by way of one gate contact 6. [Reference numeral] 7 is a shallow drain region formed from a shallow diffusion region, and 8 is a deep drain region formed from a deep diffusion region, which constitutes a separation region between the picture elements. [Reference numeral] 9 is a source line, which is disposed so as to pass over the source regions 2 of the vertically aligned picture elements, and which is connected to the source regions 2 of each picture element by source contacts 10. [Reference numeral] 11 is a drain line, which is vertically disposed between picture elements, where gate electrode joining parts 4 are not disposed, and which is connected to the deep drain regions 8 by way of a drain contacts 12.

As described above, the gate electrodes 3_{-1} and 3_{-2} of two horizontally aligned adjacent picture elements 1_{-1} and 1_{-2} are connected to the gate line 5 by way of one gate contact 4 [*sic*], whereby the surface area of the gate contact parts can be halved with respect to conventional devices wherein a gate electrode was separately connected to the gate line by a gate contact for each of the picture elements. Furthermore, because the gate contact parts are disposed between picture elements at an oblique angle to each of the picture elements, the source line can be disposed so as to pass directly over the picture elements, as in the present embodiment. Accordingly, it is possible to reduce the surface area by the amount [that would be occupied by] the source line in cases where [the source line] is disposed between vertical rows of picture elements. By disposing the source line so as to pass over the center of the picture elements, it is possible to dispose a drain line in the position where the source line is conventionally disposed. Accordingly, it is possible to dispose drain contacts close to the picture elements without increasing the surface area, allowing for stabilization of the potential of the common drain for the picture elements.

Figure 3 is a view illustrating the planar structure of a variant on the embodiment illustrated in figure 2. In this variant, the gate line 5' is formed using a thin metal film and the width of the wire is reduced, whereby, by employing diamond shapes, as shown in the drawing, for the gate contact 6' and the gate contact part of the gate line 5', it is possible to further reduce the surface area of the gate contact part, allowing for increased picture element density.

Figure 4 is a view illustrating the planar structure of another embodiment of the present invention, in which constituent elements that are identical or equivalent to those in the embodiment illustrated in figure 2 are indicated by identical reference numerals. In this embodiment, the gate electrodes of four picture elements are connected in common to the gate line by one gate contact. That is to say, extensions 3_{-1a}, 3_{-2a}, 3_{-3a} and 3_{-4a} protrude obliquely, and so as to intersect, from the gate electrodes 3_{-1}, 3_{-2}, 3_{-3} and 3_{-4} of the CMD photoreceptor elements constituting four horizontally and vertically adjacent picture elements 1_{-1}, 1_{-2}, 1_{-3} and 1_{-4}, so as to form a common joining part 4'. Then, the constitution is such that this gate electrode common joining part 4' is connected to a gate line 5 by one gate contact 6, [one of which is] disposed between every two horizontal rows of picture elements, so that the four gate electrodes 3_{-1}, 3_{-2}, 3_{-3} and 3_{-4} are connected in common to the gate line 5 by one gate contact 6.

[Reference numerals] 9_{-1} and 9_{-2} are two source lines, which are vertically aligned so as to cross over the source regions 2 of the picture elements, and which are so constituted as to alternately connect to the source regions 2 of every other picture element, by source contacts 10_{-1} and 10_{-2} on the source lines 9_{-1},9_{-2}.

By employing a constitution wherein the gate electrodes 3_{-1}, 3_{-2}, 3_{-3} and 3_{-4} of four horizontally and vertically adjacent picture elements 1_{-1}, 1_{-2}, 1_{-3} and 1_{-4} are connected to the gate line 5 by one gate contact 6 in this manner, it is possible to halve the number of gate lines conventionally used for

the overall solid-state imaging device. In this case, two rows of horizontally aligned picture element rows are simultaneously selected, and consequently, in order to read each of the picture elements that are horizontally aligned in these two rows separately, two source lines are necessary for one row of vertically aligned picture elements, as shown in the drawing, but the surface area of the chip can be greatly reduced by sacrificing a [small] amount of photoreceptor surface area.

Furthermore, at this juncture, if a constitution is employed wherein a multilayer wiring system is used so as to dispose two overlaid source lines on one side [of the source region], the reduction in the photoreceptor surface area can be minimized.

Note that, in the embodiment illustrated in figure 2, a [device] wherein a deep drain region is provided between the horizontally aligned picture elements is illustrated, but this deep drain region can be omitted in the same manner as the variant shown in figure 3 or the embodiment shown in figure 4, allowing for a further reduction in the surface area of the chip.

(Effects of the Invention)

As described above with reference to the embodiments, according to the present invention, a constitution is employed wherein a plurality of CMD photoreceptor element gate electrodes are connected to the gate line by one gate contact, allowing for a reduction in the surface area of the gate contact parts, so that the chip size can be reduced and the picture element density can be increased.

Furthermore, by employing a constitution wherein a plurality of gate electrodes are connected in common to the gate line by one gate contact, the degree of freedom with which the source line and the like can be disposed is increased, allowing for more optimal wiring, so that a compact and high-resolution solid-state imaging device can be produced.

4. Brief Description of the Drawings

Figure 1 is a conceptual view illustrating the basic constitution of a solid-state imaging device according to the present invention; figure 2 is a view illustrating the planar structure of an embodiment of the present invention; figure 3 is a planar structural view illustrating a variant of the embodiment illustrated in figure 2; figure 4 is a view illustrating the planar structure of another embodiment of the present invention; figure 5 (A) and (B) are views illustrating the planar structure, and a section, of a conventional solid-state imaging device using CMD photoreceptor elements.

In the drawings, 1_{-1}, 1_{-2}, 1_{-3} and 1_{-4} indicate picture elements comprising CMD photoreceptor elements; 2 indicates a source region; 3_{-1}, 3_{-2} 3_{-3} and 3_{-4} indicate gate electrodes; 4 and 4' indicate gate electrode joining parts; 5 and 5' indicate gate lines; 6 and 6' indicate gate contacts; 7 indicates a shallow drain region; 8 indicates a deep drain region; 9, 9_{-1} and 9_{-2} indicate source lines; 10, 10_{-1} and 10_{-2} indicate source contacts; 11 indicates a drain line; and 12 indicates a drain contact.

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FIG. 1

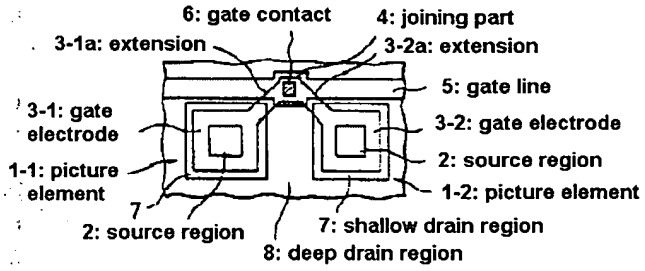


FIG. 2

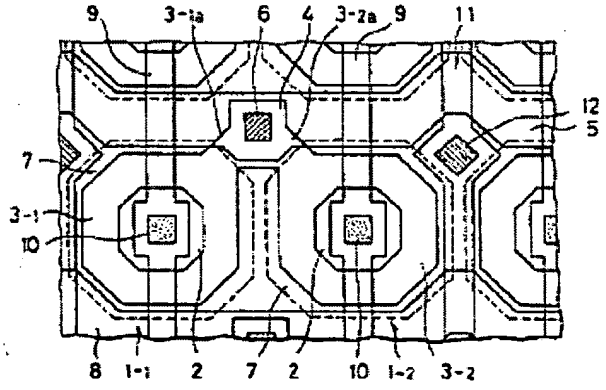


FIG. 3

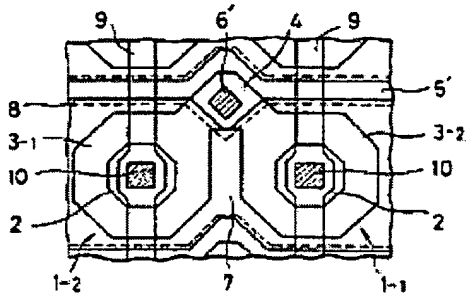


FIG. 4

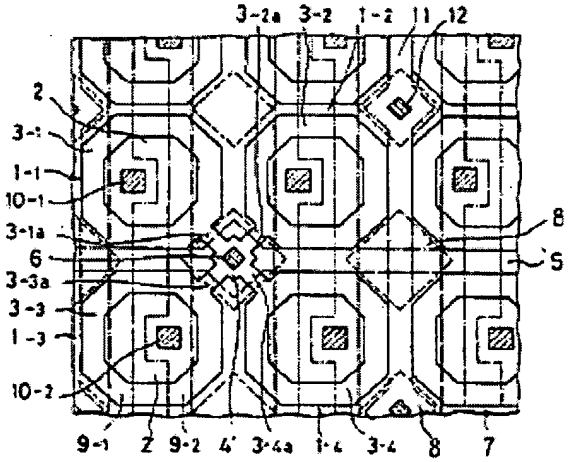
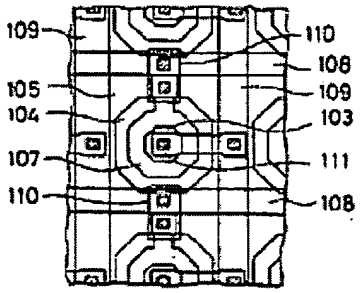


FIG. 5

(A)



(B)